Differences in the Spatial Distribution of Japanese Larch Stands in Mountains with Differing Bedrock

Sadao Takaoka

Abstract

Spatial patterns of *Larix kaempferi* occurrence were characterized in mountains with differing bedrock. The distribution of *L. kaempferi* stands and landslide patches in the Kamikochi Valley of central Japan was mapped, using field surveys and aerial photo interpretation. The shape, density and size-distribution of *L. kaempferi* stands and landslide patches in areas with granitic bedrock differed from those in areas with sedimentary bedrock. Small, narrow elliptical patches of *L. kaempferi* occurred frequently in granitic bedrock areas, while patches of *L. kaempferi* in sedimentary rock areas were few in number, but sometimes large in area. This heterogeneous spatial pattern of *L. kaempferi* patches is probably caused by differences in disturbance regimes, which depend on bedrock conditions.

1. Introduction

Japanese larch (*Larix kaempferi*), a pioneer deciduous conifer, is widely distributed in mountainous areas in the Chubu Region of central Japan (Fig. 1 a). *L. kaempferi* can be a key species for the analysis of the relationship between geomorphic processes and forest regeneration, because *L. kaempferi* forests mainly occur on slopes where the ground is frequently disturbed. In the autumn, the color and shape of *L. kaempferi* crowns are so distinctive that they can be easily detected on aerial photographs. This enables the interaction between biotic and abiotic factors to be studied at a large spatial scale, with the use of aerial photo interpretation.

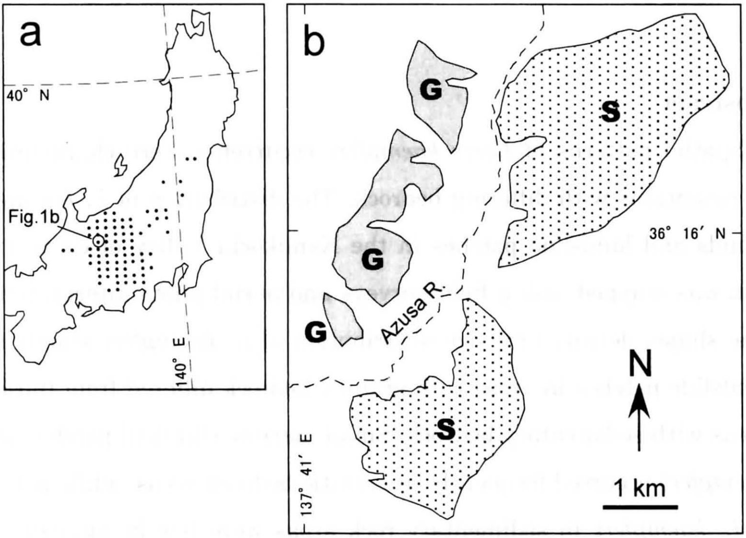

Fig. 1 Distribution of *Larix kaempferi* in Japan (after Horikawa, 1972), and a map showing the study areas underlain by granitic rocks (G) and by sedimentary rocks (S).

L. kaempferi forests are often found in volcanic mountains in the Chubu Region, where *L. kaempferi* colonizes bare ground composed of scoria or lava (Maeda *et al.*, 1978 ; Sasaoka *et al.*, 1999). In non-volcanic mountains, this species forms forest stands in and around landslides (Kawasaki, 1992 ; Baba and Ito, 1995), riverbeds (Ishikawa *et al.*, 1978 ; Takahashi and Nashimoto, 1980 ; Baba, 1989 ; Baba and

Ito, 1995), and alluvial cones (Takumi et al., 1988 ; Ito and Marutani, 1993) where erosion and sedimentation occur frequently. The Chubu Region has had one of the highest rates of uplift in Japan during the Late Quaternary (Sakaguchi, 1980), suggesting that erosion and sedimentation are very active in this region, and that sites suitable for the regeneration of *L. kaempferi* tend to be created frequently.

In non-volcanic mountain areas of the Chubu Region, the spatial distribution pattern of *L. kaempferi* is not homogeneous ; distribution seems to depend on the type of bedrock. This difference in spatial distribution may be caused by differences in geomorphic processes occurring in each bedrock type. *L. kaempferi* thrives in areas with bedrock that undergoes frequent erosion and sedimentation.

This paper examines areal differences in the occurrence of *L. kaempferi* on mountain slopes and the effects of landforms. The objectives of this study were to describe differences in the spatial distribution of *L. kaempferi* and to examine the relationship between landslide occurrence and the establishment of *L. kaempferi* forests.

2. Study area and methods

2–1. Physical setting of study area

This study was conducted in the Kamikochi Valley, which is located in an upstream region of the Azusa River Basin, in Nagano Prefecture, central Japan (Fig. 1 b). The study area is located in the lower part of the subalpine coniferous zone. *Tsuga diversifolia* is the dominant tree species in this zone, while *Thuja standishii, Abies homolepis,* and *Picea jezoensis* var. *hondoensis* occur less frequently. *L. kaempferi* and *Betula ermanii* usually invade disturbed sites on

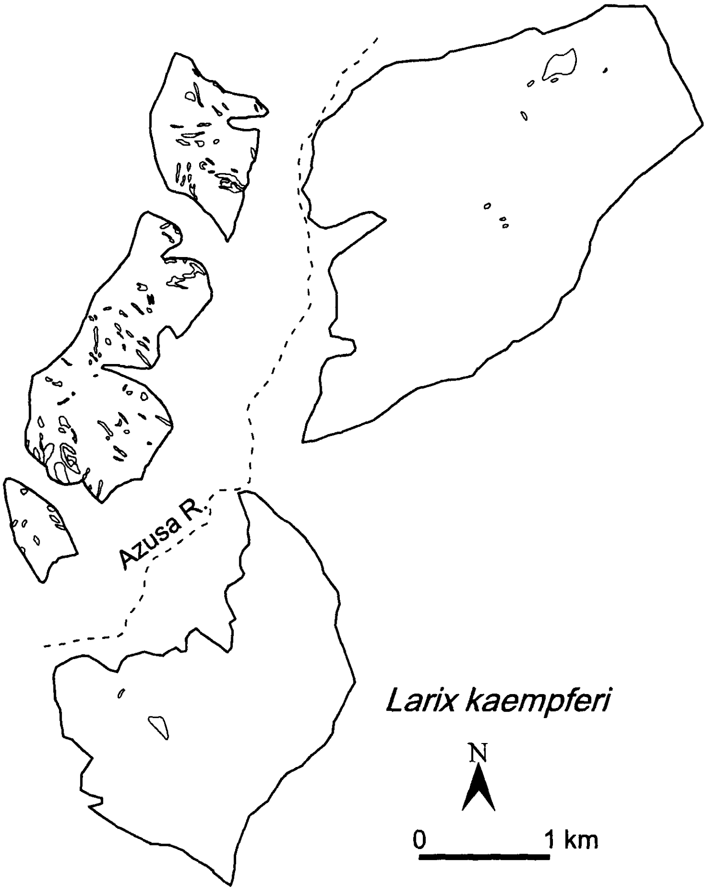

Fig. 2 Distribution of *Larix kaempferi* stands.

mountain slopes. *L. kaempferi* often forms narrow, elliptical stands, while *B. ermanii* is usually scattered sparsely in evergreen coniferous forests.

The nearest meteorological station is the Kamikochi Station, which is 6 km southwest of the study area, at an elevation of 1520 m above sea level. The mean annual precipitation is 2703 mm, and the mean annual temperature is 6.2 C°.

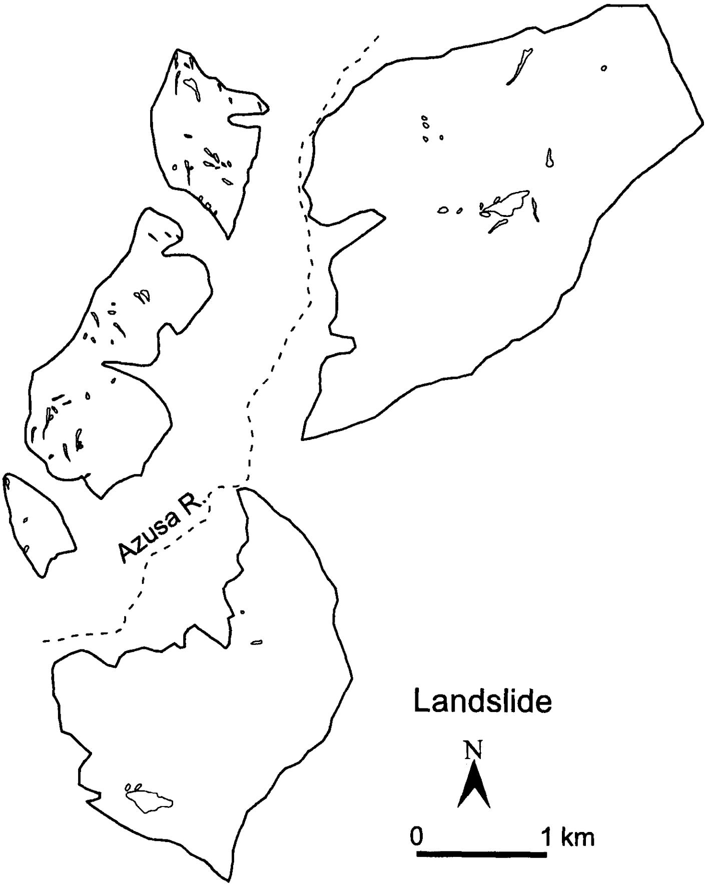

Fig. 3 Distribution of landslide patches.

The bedrock in the study area is composed of andesite, granitic rocks and Paleozoic–Mesozoic sedimentary rocks (Harayama, 1990). The spatial distribution of *L. kaempferi* seems to differ in mountains with the different bedrock.

2–2. Methods

Three areas with granitic bedrock and two areas with sedimentary bedrock were investigated. Within these areas, *L. kaempferi* stands and landslide patches were both mapped on 1 : 25000 topographic maps, using 1994 aerial photographs. *L. kaempferi* patches with different canopy heights and/or diameters were mapped as different patches. The landslide patches that were mapped include non-vegetated land formed by debris flows. Patches larger than 0.03 ha were digitized, and the area of each patch was computed using a geographic information system. Slope inclination was measured at the center of each patch. In addition, 100 by 100-m grids were superimposed on 1 : 25000-topographical maps covering the five areas, and the slope inclination for each grid point was calculated.

3. Results

The distribution of *L. kaempferi* stands and landslide patches is shown in Figs. 2 and 3. Small, narrow elliptical patches of *L. kaempferi* occurred frequently in areas with granitic bedrock, but *L. kaempferi* occurred infrequently in areas with sedimentary bedrock. However, large patches of *L. kaempferi* occasionally occurred in areas with sedimentary bedrock. The shapes and spatial patterns of the landslides were similar to those of the *L. kaempferi* patches.

The size distribution of *L. kaempferi* and landslide patches indicated that most patches were smaller than 0.2 ha, in both granitic and sedimentary bedrock areas (Fig. 4). Larger patches occurred less frequently. However, a few *L. kaempferi* stands and landslide patches larger than 3 ha were found in areas with sedimentary bedrock.

The slope inclination of *L. kaempferi* stands and of landslide patches were greater in areas with granitic bedrock than in areas

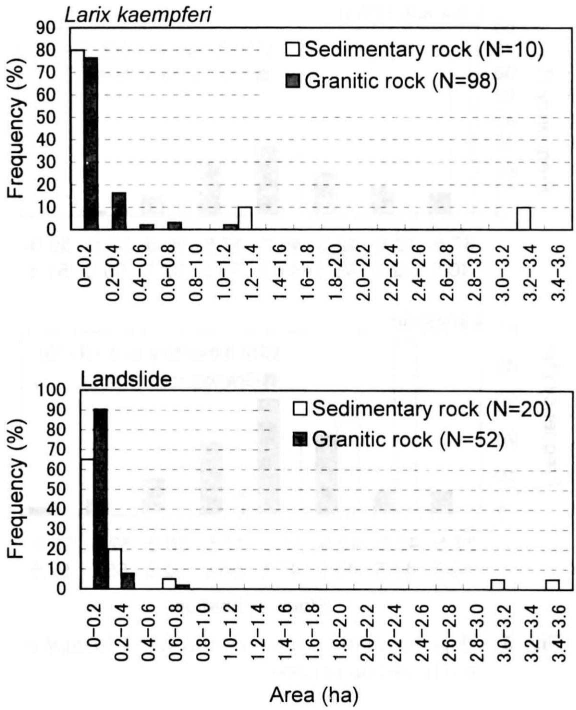

Fig. 4 Distribution of the area of *Larix kaempferi* stands and landslides.

with sedimentary bedrock as shown in Fig. 5. Within granitic bedrock areas, the frequency of occurrence of *L. kaempferi* stands and landslide patches was highest within the class of slope inclination ranging from 45.0–47.5 degrees. The range and form of *L. kaempferi* distribution were similar to those of the landslide distribution in areas with granitic bedrock.

Areas with granitic bedrock generally had steeper slopes than areas with sedimentary bedrock (Fig. 6). The average slope inclination was greater in areas with granitic bedrock than in sedimentary bedrock areas. However, in the sedimentary bedrock areas, there were more

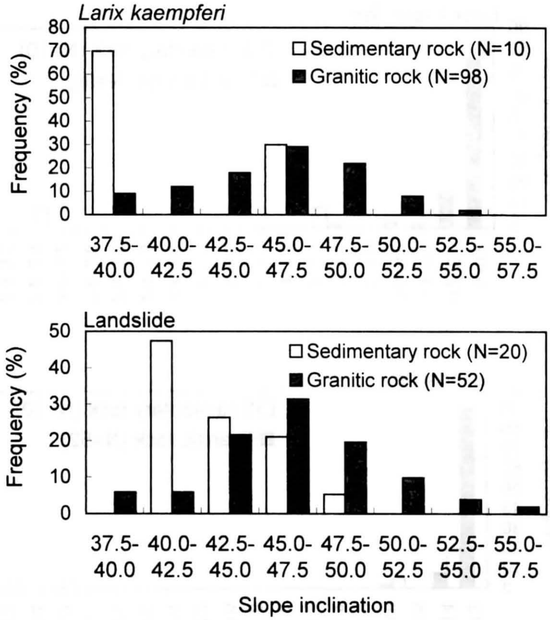

Fig. 5 Slope inclination, measured in *Larix kaempferi* and landslide patches.

grid points of steep slopes (42.5–50.0 degrees) where landslides occurred frequently as shown in Fig. 5.

4. Discussion

The shape, density and size distribution of *L. kaempferi* stands and landslide patches in areas with granitic bedrock were different from those in areas with sedimentary bedrock (Figs. 2, 3 and 4). However, the spatial patterns of *L. kaempferi* stands were similar to those of the landslide patches within areas of each bedrock type. There was no marked difference between the distributions of slope inclination in *L. kaempferi* and landslide patches, particularly in granitic rock areas (Fig. 5). These observations suggest that most patches of *L. kaempferi*

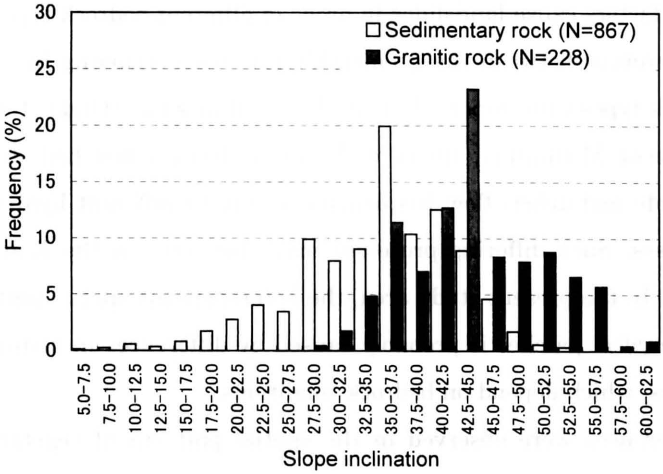

Fig. 6 Slope inclination, measured at grid points plotted throughout the study areas.

on the mountain slopes were established following landslides, and that other factors not involving ground disturbance (e.g., wind) may have been less important for *L. kaempferi* regeneration. The occurrence of bare ground appears to be important for the establishment of *L. kaempferi*, which can colonize such sites because of its strong resistance to drought (Yura, 1988). Most landslide patches will probably become covered by *L. kaempferi* patches, except on slopes steeper than 55 degrees (Fig. 5).

The steepness of slopes does not seem to be an important reason for the higher occurrence of landslides in areas with granitic bedrock, although, in general, slopes were steeper in granitic rock areas (Fig. 6). Despite the higher number of steep slopes (42.5–50.0 degrees) occurring in areas with sedimentary bedrock, fewer landslides were actually found on these slopes. The number of landslides per unit of land area was higher in areas with granitic bedrock. This suggests that different factors cause landslides in areas of different bedrock type.

Differences between the geomorphic processes occurring in the two bedrock types were reported in the Uetsu Mountains (Onda, 1994). In the Uetsu Mountains, areas with two bedrock types had differing landslide and debris flow frequencies, owing to different hydrological processes. Such differing processes may also occur in the Kamikochi Valley. In the present study area, the heterogeneous spatial pattern of *L. kaempferi* patches is probably caused by differences in disturbance regimes, which depend on bedrock conditions.

Differences were observed in the spatial patterns of vegetation in areas with the two bedrock types, even on alluvial fans along the Kamikochi Valley. Further analysis should be conducted in such sedimentation sites, as the present study deals only with larch stands on erosion sites on mountain slopes.

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